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WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 54

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WEST AFRICAN COCOA RESEARCH INSTITUTE

TAFO, GHANA

FIFTY-FOURTH QUARTERLY REPORT

APRIL-JUNE, 1959.

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in W.A.C.R.I. Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb
Deputy Director	C.G. Johnson (on leave 22/4/59, pending termination of secondment).
Scientific Assistant to Director	G.A. Jones
Secretary	H.L. Pugh (on leave)
Accountant	H.J.S. Mill
Assistant Accountant	J.N.A. Hyde (on leave 12/5/59)
Office Assistant/Librarian	D.J. Ellis (Miss)
TAFO STATION	
Division of Entomology	C.G. Johnson (on leave 22/4/59, pending termination of secondment)
	E. Dunn
	P.F. Entwistle (on leave 23/6/59)
	M.R. Smith
	K.B. Armstrong
Division of Pathology	J.W. Blencowe
	A.L. Wharton
	A.A.F. Brunt (on leave 5/4/59)
	P.D. Turner
	A. Attafuah
Division of Botany	D.R. Glendinning
	R.G. Hurd
Division of Chemistry	R.H. Kenten (on leave 1/5/59)
	R.K. Cunningham
Division of Agronomy	R.W. Smith (on leave 10/6/59)
	T.H.R. Hall (arrived 9/4/59)
Statistician	C. de Jonge
Laboratory Technicians (Electronics)	A.J.H. Arnold (on leave 8/4/59)
(Spectrography)	J.C. Burridge (on leave 24/5/59)
Plantation Manager	H.W.S. Allison
Maintenance Engineer	A. Maddison (on leave 8/4/59)
	G.O. Hayward (arrived 24/5/59)
Works Superintendent	E.K. Berko
Guide-Demonstrator	F.E. Decker
Station Manager	S.E. Ntim-Kwafo (returned from leave 3/6/59)
Medical Officer	P.K.K. Knudsen
IBADAN SUB-STATION	
Deputy Director (Nigeria)	T.W. Tinsley (on leave)
Entomologists	R.G. Donald
	C.K.H. Martini
Pathologists	H.M. Thresh (on leave)
	D. Kay
Agronomist	J.F. Longworth
WEST AFRICAN FUNGICIDES RESEARCH UNIT	
Mycologist	E.C. Hislop
Chemist	P.O. Park

STAFF MATTERS

Dr. C.G. Johnson returned to Rothamsted Experimental Station in April, Mr. A. Maddison left the Institute in April and Mr. A.J. Arnold, and Mr. A.A.F. Brunt went on leave in the same month. Mr. R.H. Kenten and Mr. J.C. Burridge went on leave in May and Mr. R.W. Smith went on leave in June. Mr. E.C. Hislop joined the staff of the Ibadan sub-station in May. Mr. Hislop, who transferred from the Colonial Pesticides Research Unit, returned to Nigeria from leave in June.

Staff Movements

Dr. Martini and Mr. Kay visited the cocoa growing areas of the Cameroons. They were accompanied by Dr. Hurd from Tafo. Mr. Kay also inspected cocoa in the Eastern Region, and Mr. Long-worth visited Lafiaji, Northern Region, where cocoa is grown under irrigation.

VISITORS

During May the Institute was honoured by a visit from the Earl of Home and by Mr. H. Gaitskell, Leader of the U.K. Parliamentary Opposition. A Yugoslav Trade Mission visited the Institute in April and other visitors during the quarter have included, Mr. T.O. Asare; Mr. H.A.M. Clark, O.B.E., Training & Recruitment, Sierra Leone; Mr. Kenneth Younger, U.K. Labour M.P.; Mr. G. Merny and party from the Institute d'Enseignement et de Recherches Tropicales; a party of five parliamentarians from French Togoland; Mr. K. Newton, Dept. of Agriculture, New Guinea; and Mr. D. Banks, Agricultural Adviser to the U.S. Operation Mission. In addition to the above, several parties of Agricultural Field Assistants, students from various schools and colleges, learners from Agricultural Training Centres at Kwadaso and Nyankpala and members of various societies and clubs were also shown round the Institute.

In April the sub-station was honoured by a visit of His Excellency the Governor-General of the Federation of Nigeria and Lady Robertson. Other visitors during the quarter included the Chairman and members of the Western Region Marketing Board, Messrs. Chevaugson, Goujon, Merny, and Luc of the Institute d' Enseignement et de recherches Tropicales, Dr. H. Roberts of W.A.T.B.R.U., Messrs. Enabiofo and Are of the Western Region Production Development Board and a party of Agricultural Superintendents in training from the Western Region Ministry of Agriculture and Natural Resources.

AGRONOMY DIVISION

COCOA: UNIFORMITY TRIAL AREA - STATION FARM

Routine harvesting commenced on the 7th April and was completed on June 24, with yields as shown in Table I.

Table I

Date of Picking	Total Pods		% Pod Discards	Pods Fermented	Wet Wt. of beans z calculated (1)	Dry Wt. of beans x calculated (2)
	Harvested	Discarded				
1959						
April 7 - 30	12,820	1,279	10.0	11,541	2308.2	961.75
May 18 - 29	6,718	928	13.8	5,790	1158.0	482.5
June 22 - 24	1,446	119	8.3	1,327	265.4	117.6
TOTAL	20,984	2,326	11.1	18,658	3731.6	1561.85

z 1. Calculated on basis of 5 pods to 1 lb.
x 2. " " " " 12 " " 1 lb.

TREE MORTALITY

Trees removed during the quarter due to swollen shoot infection and other causes.

Table II

Month	Trees destroyed		Total	No. of seedlings removed
	Swollen Shoot	Undiagnosed		
1959				
April	46	-	46	33
May	34	2	36	47
June	69	1	70	18
TOTAL	149	3	152	98

FERTILIZER APPLICATION

A third application of fertilizer was applied to an area of 67.60 acres of various experiments on the station and the square mile. Commencing on the 14th April, it was completed by the 26th of May.

SQUARE MILE:

Experimental plots

The total yield from all the Agronomy experimental

plots for the quarter shows an increase of nearly sixty per cent over that of the same period last year.

Figures for the quarter are compared with those of last year.

Experiment	1959 April-June	1958 April-June
U.A. Spacing Trial	8,331	15,289
U.A. Extension	2,986	2,860
U.A. Multiplication	13,903	7,732
Amelonado Spacing Trial	10,868	11,886
Factorial Fertilizer Trial	7,011	1,644
2nd Establishment BI	4,017	1,787
" " BII	7,209	6,615
Uniformity Trial	29,490	8,519
Amelonado Pruning Trial	1,240	532
" Source Trial	1,388	462
Shade and Manurial Trial	17,820	8,673
TOTAL	104,263	65,999

COVER CROP AND MULCHES EXPERIMENT

Planting of plots and non-experimental trees was carried out on the 7th and 8th of May. The few planting casualties were replaced towards the end of the month. Routine maintenance of plots followed in June.

IRRIGATION TRIAL

With exception of few trees which have had insect attack on the leaves, the cocoa in this experiment are growing well. Routine maintenance included, during the month, the removal of all the decaying logs on the experimental site.

METEOROLOGY

Rainfall in inches and number of wet days during the quarter compared with the past 21-year means.

Month	1959		Past 21-year means	
	Rainfall (ins.)	Wet days	Rainfall (ins.)	Wet days
April	6.68	13	6.06	11.1
May	9.36	15	7.57	14.0
June	7.72	18	8.61	18.9
TOTAL	23.76	46	22.24	44.0

PATHOLOGY DIVISION

VIRUS RESEARCH

Virus symptoms are now appearing on the trees that were infected in the experiments described in Quarterly Report No.53. There is as yet no detectable decrease in yield of the infected trees.

Experiment E1, a variety trial designed to compare the resistance and tolerance of certain types of cocoa to virus infection has been planted during the quarter. In this experiment a series of nine crosses have been made between Amazon parents:

T61/1239	x	T61/1664
T61/1313	x	T61/1403
T62/891	x	T62/977
T81/1792	x	T81/1880
T81/1880	x	T81/1792
T86/956	x	T86/1600
T16/613	x	T17/359
T17/359	x	T17/433
T17/433	x	T17/359

The progeny have been planted in plots of twelve trees separated from each other by guard rows of Amelonado cocoa, there are control plots of both Amelonado and F2 Amazon cocoa. The plots are arranged in randomised blocks, most of the treatments are replicated eight times, but there was only sufficient material to plant four replicates of a few of the progenies. The trees have been planted at a spacing of 8 ft. x 8 ft. with temporary tree-cassava shade. The experiment occupies about 3 acres, four of the blocks are on clear-felled land, four have very light forest-tree shade, consisting of about 25 medium-sized trees per acre. When the trees in the experiment have grown to form a continuous canopy, the Amelonado guard-rows will be infected with a severe isolate of swollen shoot virus which will be allowed to spread un-checked through the experiment. This should yield information both on the field resistance to infection of the progenies, and on the effect on growth and yield. An experiment using some of the same varieties of cocoa has also been planted in Nigeria.

Most of the experiments on the capsid-spraying of virus-infected cocoa that are being made in collaboration with the Division of Agriculture (Quarterly Report No.53), have now commenced. Ten units (each unit is made up of one treated and one un-treated plot) have been sited in an area affected by a severe strain of swollen shoot virus, eleven units in an area of relatively mild virus and three units in an area where there is a complex

of mixed infections with a severe and a mild virus. Three units are being started in an area devastated by virus disease and capsid injury in the west of Ghana, these are the only experiments not within the area of the Eastern Province.

STUDIES ON BLACK-POD DISEASE

Resistance and Tolerance

A site has been chosen for a trial primarily designed to study the inheritance of resistance to Phytophthora pod disease. The experiment will be situated on the high scarp at Mpraeso on two cocoa farms that have been virtually abandoned by the owners because of the high incidence of pod disease. A blight of young flush leaves and of chupons in these farms has proved to be caused by Phytophthora palmivora. The fungus has been isolated, identified in sections of tissue and successfully inoculated into un-wounded seedlings. Of 45 Amelonado and Amazon seedlings left on the site for 10 days, 15 which had only one flush of young un-hardened leaves were completely killed. The remainder were all infected through young flush leaves and severely damaged. (Flush-leaf infections with Phytophthora have also been recorded at W.A.C.R.I. on Herrania antioquia and Clone Lafi 7).

If negotiations for the use of the land are successful the land will be cleared and planting will commence in early 1960. Pollinations involving 16 crosses have been made by the Botany Division. The parent material for these crosses include 5 Trinitarios (4 resistant, one highly susceptible), 1 selected Amelonado, and 1 Upper Amazon type. It may also be possible this year to propagate sufficient material of two clones, Lafi 7 from Samoa, and 12B from the French Cameroons, for inclusion in the trial.

Testing of selections for tolerance to bark infection by measuring the length and diameter of lesions developed from artificial inoculations has been initially unsatisfactory. Five inoculations were made on each selection and this proved to be too small a sample as the lesions produced were extremely variable. There were no striking differences between the growth of lesions in any of the selections tested in the 1st Clonal and 9th Progeny Trials.

FUNGICIDE SPRAY CONTROL TRIALS

An experiment has commenced to examine the possible use of light mineral oil to control black-pod disease. Spraying at three-weekly intervals and six-weekly harvesting of the Upper Amazon Spacing and Pruning Trial commenced on April 10th, 1959. The first two oil applications were with Shell S2686 (U.R.95) and

the remainder with Shell Vapona E. (U.R.96). Results to date are in the table below :

Spacing	Replicate No.	Total Pods	No. black-pods	% black-pod	
8 x 8	3	629	42	6.7	Treated
8 x 8 P	2	495	30	6.1	
10 x 10	1	257	17	6.6	
10 x 10 P	4	853	18	2.1	
12 x 12	2	323	6	1.9	
12 x 12 P	3	597	16	2.7	
Total	15	3154	129	4.1	
8 x 8	2	299	40	13.4	Control
8 x 8 P	3	522	29	5.6	
10 x 10	4	1108	52	4.7	
10 x 10 P	1	187	6	3.2	
12 x 12	3	907	35	3.9	
12 x 12 P	2	347	5	1.4	
Total	15	3370	167	5.0	

P = pruned to 1st jorquette.

THE RELATIONSHIP BETWEEN HOST AND PARASITE

Monthly records of lesion development in pods from the four treatments of the Shade and Fertilizer trial have shown that there is a complex interaction between the two factors and the rate of fungal growth. This is more marked when inoculated pods remain attached to the trees. The experiment will be continued for several months.

ENTOMOLOGY DIVISION

JOINT WACRI/DIVISION OF AGRICULTURE MEALYBUG CONTROL TRIALS

Mealybug studies

A trial to test the efficiency of different formulations and methods of application of dieldrin to control ants, has been laid down at Bunso, Bosuso and Osino areas. It is intended that the following treatments will be applied.

1. Trunk application of a 0.67% solution (1 lb. toxicant in 20 gallons of water) with a motorised mist-blower sprayer to the first 8-10 feet of trunk; the volume applied being geared to the tree density rather than acreage.

2. Spray-banding using a 1.25% solution (1 lb. toxicant in 10 gallons of water) applied with pressurised knap-sack sprayers to a 2 foot deep zone round the trunk of each cocoa tree. It is envisaged that where areas of primary and secondary forest occur within a plot they will have to be treated with motorised mist-blower sprayers as in 1.

3. Trunk-banding applied with paint brush using a 10% Urea formaldehyde-dieldrin laquer (Tapley's formulation as used against coffee stem borers in East Africa).

4. Lower trunk and ground litter application with a 1.25% solution; applied with baffled motorised mist-blower sprayer in such a manner that will prevent upward drift into the tree canopy.

5. Untreated controls.

Pre-treatment counts of ant and mealybug populations, to hand-height, have been made on all the plots. Further ant and mealybug population counts will be made at fortnightly intervals for the duration of the experiment.

The incidence of minor pests, and in particular, the mining and wood boring species, will also be recorded to observe any changes in population balance which may result from the different types of treatment.

Oyoko. Ant/Mealybug trials

Ant populations are continuing to increase considerably and re-establish active nests. The recovery of the mealybug populations is also showing an upward trend, but the numbers are still lower than pre-treatment levels.

Further dieldrin applications will not be made, and vector population will be allowed to recover. Fuller details of this experiment, including observations on decline of virus incidence in the treated area, will be found in the 1958-59 Annual Report.

CAPSID STUDIES

In Ashanti the trials with Endrin, Aldrin and Gammalin (see Quarterly Progress Report No. 50), are continuing; in addition, yields and pod husk miner damage are now being recorded.

MARMARA STUDIES

A sufficient amount of data on the incidence and biology of the pod husk miner (see Quarterly Progress Report No. 47) has been accumulated, and this investigation has now been terminated. A full account of the work will be published later.

SYSTEMIC INSECTICIDES

Field tests have been commenced and methods of

application and dosage rates are being determined for Rogor 40. Seedling tests concerned with stem, soil and leaf application are also being continued.

LABORATORY ASSESSMENT OF INSECTICIDE

A technique for breeding and rearing capsids on pods is proving satisfactory. Adult capsids are caged in wire gauze sleeves around individual pods. When the first nymphs emerge from the egg the cage is removed. This work is being continued to determine if it will be possible to dispense with field collected capsids for laboratory bio-assay tests.

LEAF EATING LEPIDOPTERA

Collection and rearing of Lepidopterous larvae from cocoa has been continued. Many species are now awaiting identification at the Commonwealth Institute of Entomology and more will be sent when good series have been bred.

MINOR PESTS

Cerambycidae

The chalcidoid egg parasite, mentioned in Quarterly Progress Report No.53, has now been identified at the Commonwealth Institute of Entomology as :-

Aprostocetus sp. nr. diplosidis Crawf. (Eulophidae).

Lepidoptera

The Commonwealth Institute of Entomology have also made the following identifications :-

Amicrocentrum sp. (Braconidae), a parasite of the larval stages of Eulophonotus myrmeleon Feld., and Meteoridea sp. (= Benama Nixon) (Braconidae), a single specimen of which has been reared from the pupa of a moth belonging to the family Metarbelidae, and probably to the genus Metarbela. This moth has been noted at Oyoko, in association with E. myrmeleon, both species having been present in unusually high numbers following dieldrin spraying in the ant/mealybug control trial area.

BOTANY DIVISION

PLANT BREEDING AND SELECTION

Several experiments on seedlings conducted in the nursery have been completed, and the data are being studied.

The following field experiments have been planted at Tafo:-

1. A comparison of an Amazon Amelonado cross to its reciprocal.

2. A comparison of crosses of a Nanay type, a Parinari

type, and a hybrid between the Nanay and Parinari types to Amelonado.

3. A comparison of several crosses between Amelonado from different sources in Ghana, an Amelonado-like type from Brazil, and the near-Amelonado clone N38.

4. Small plots of crosses of Nanay, Parinari, Scavina, Morona, Ecuador and Surinam types etc. to Amelonado, for observation of genetic segregation.

5. A small trial comparing four different types each budded onto four different rootstocks.

All the above experiments are small, the total area being under two acres.

6. A 4½ acre block of five of the new varieties and F1 T63 for general observations. It is intended that this area shall receive fertilizer, and be given the best agronomic treatment possible.

Seedlings of the varieties have been supplied to the University for planting at Kade, and to the Division of Agriculture for planting at Apedwa.

The plant breeder visited Sierra Leone in April to advise on experimental work, including variety trials, to be undertaken at Kpuwabu. A report has been despatched.

A report on the present situation regarding the varieties, their performance at various sites, their quantity etc. has been prepared for circulation.

ESTIMATING TREE SIZE FOR CLONAL CACAO

The number of leaves on a cacao tree probably gives the best estimate of tree size. However total leaf counts are very tedious and it is known that the diameter of the trunk also gives a good estimate. The correlation coefficient between the square of the trunk diameter and leaf number of 24 seven year old Amazon trees grown from seed was 0.78. (Highly significant).

However clonal cacao has an irregular trunk which often branches at or just above soil level and this may reduce the correlation. The diameters of the trunks of 24 seven year old clonal cacao trees (selection E9) were taken at a point one foot up the trunk from ground level. (Since the trunk is inclined at an acute angle to the ground this does not correspond with the diameter measured one foot above ground level). A correlation of 0.88 was obtained between the square of the diameter and the number of leaves on the tree. An additional measurement of the diameter at a distance of two feet from ground level was made and

the mean diameter calculated. This resulted in no improvement in the correlation (0.89).

It appears that trunk diameters give a good estimate of tree size in cacao with both types of growth habits. Since the figure obtained is only relative it will not necessarily have the same value for trees of different selections of the same size.

PHYSIOLOGY OF NUTRITION AND GROWTH

Nutrient culture - Boron and copper deficiency

Growth of plants in both sand and water culture improved over this period. Symptoms of deficiency in the leaves were not observed until 3 months after the plants had been transplanted from baskets (when they were 3 weeks old). Copper deficiency symptoms were more severe than those of boron deficiency. Both symptoms were observed in the treatment in which both boron and copper are deficient although the plants were more vigorous than in either of the single deficiency treatments. This suggests that the ratio of B to Cu rather than the absolute amount supplied is an important factor in limiting the growth of the plant.

Apart from the reduction in growth rate the most characteristic symptoms of copper deficiency are seen in the young expanding leaves. The external margins of the distal region of the leaf collapse and start to shrivel. Often up to 2/3rds of the margin of the leaf is affected and since this occurs while the leaf is expanding it becomes deformed into a boat or inverted boat shape with puckered interveinal regions. The necrotic margins become stretched and tend to roll longitudinally. Although the leaf tip may not be affected at first there is a tendency for the distal part of the leaf to stop developing, and this area subsequently becomes necrotic also. If the deficiency is mild the leaf matures with only a tip chlorosis or necrosis extending about ¼ of the way back along the leaf. If it is severe the leaf abscisses as soon as it is distinguishable although the stipules persist.

In certain wet areas the tips of young leaves are particularly susceptible to attack by pathogens. This leads to a tip necrosis in the mature leaf similar to that just described. This can be confusing unless the marginal collapse of the young leaves is also present. Chemical analysis should provide a reliable method of distinguishing the two; the actual amounts of copper present in the deficient plants will be estimated later in the experiment.

For some reason a severe deficiency of boron has not been obtained in either sand or water culture. Plants which have

been transplanted into deficient solutions after 3 months in the soil show no symptoms or depression of vigour after 2 months in culture. Those which were transplanted after 3 weeks in soil are considerably less vigorous than the controls and after 3 months little new growth occurred. The new leaves were paler than normal and had wavy margins but were normal in shape. These symptoms were much more noticeable in the plants which were lacking both copper and boron. Perhaps the greater amount of growth in these plants reduced the overall boron concentration more than in the smaller plants growing in the solutions deficient in boron alone.

The growth of the control plants in water and sand culture which had been transplanted from baskets of soil after 3 weeks has been compared with seedlings of the same age growing in soil. After 4 months under approximately the same shade conditions it was found that the leaf area and number of leaves of plants in sand culture was twice as great as those in water culture and four times that of those in soil.

Growth analysis

In a preliminary experiment 3 month old seedlings were placed under different shade conditions for 8 weeks and their growth rates subsequently recorded over a 2 week period. The variability of the results showed that a replication of 50 plants per harvest would have been necessary to detect significant differences between the mean values for N.A.R. and R.G.R. obtained in this experiment. The experiment is being repeated using this number of replicates taking care to ensure uniform material as far as possible by selecting bean size over a small range. The beans will be sown in whalehide pots and they will be transplanted to prepared beds under the different degrees of shade 8 weeks from sowing. The beds have been given fertilizer, treated with insecticide and covered with a Guatemala grass mulch. They will stay in these beds 4 weeks before they are harvested for the analysis over a two week interval.

CHEMISTRY DIVISION

SOIL FERTILITY

A. Field Experiments

The analyses of the Joint WACRI/Division of Agriculture Fertilizer Experiments revealed that, under shade in the initial stages, phosphate produced significant responses. The second phase of these trials will concentrate on phosphate studies.

A 2^4 NPKMg nutritional pot experiment began in June. This is the follow up of a similar experiment conducted last season.

B. Laboratory Work

Chemical and physical analyses of cocoa soils continue.

Cocoa Preparation and Quality

Fermentation investigations continue.

Spectrographic Laboratory

Initial calibration of the spectrograph has begun.

I B A D A N S U B - S T A T I O N

PATHOLOGY SECTION

VIRUS RESEARCH

Cacao Necrosis Virus

The outbreak of Cocoa Necrosis Virus at Omi-Aboderin has been re-numbered in April. When the outbreak was discovered in 1956, the trees were growing very unsatisfactorily as a result of capsid attack. They have since been sprayed regularly against capsids and observations indicate that there has been no spread for about 10 months and possibly much longer. It seems therefore possible that capsid control has influenced spread and capsids are now being tested as vectors of Cacao Necrosis Virus.

Graft transmission of cocoa viruses using leaf-tissue

Further transmission tests using leaf tissue have given satisfactory results provided that the test seedlings were about twelve months old. With cocoa beans and seedlings from 2 weeks to 10 months old the percentage of infection varied between 5 and 50%. The inoculum should be taken from fully hardened but not old leaves with permanent leaf symptoms formed during the acute phase of infection.

No transmissions have been obtained with leaf pieces from immature leaves. It seems that the ability of either young leaves and young seedlings to form callous tissue is less developed than in Citrus spp. Even in old seedlings the union seems to be only temporary as none of the leaf pieces has survived more than 45 days.

Attempts have been made to graft single cocoa leaves onto cacao seedlings following the procedure described by Natrass (Ann. appl. Biol., 31, 310, 1944) for the transmission

of a virus form Passiflora. There was no union between scion and rootstock though most of the leaves wilted only slowly and no transmissions have been obtained during two months of observation. The transmission of the virus from Passiflora would probably succeed through any wounds as it is mechanically transmissible.

Observations on mealybug feeding

Earlier experiments to feed mealybugs on agar (W.A.C.R.I. Annual Report 1952/53) have been repeated. All stages of Pseudococcos njalensis Laing and Planococcus citri (Risso) settled well and the majority stayed there even after they were overgrown by fungi. Adult P. citri would even reproduce. Cellophane membranes and thin polythene sheets spread over bottle necks and fastened by rubber bands served as control media. The settling behaviour was identical on all three surfaces tested and this may indicate that no feeding takes place on agar. About 80% of the insects settled on smooth surfaces, but if troughs were cut in the agar, or folds were made in the cellophane or polythene, settling was improved to about 90%. When cellophane or polythene were spread over water the insects usually walked off within ten minutes.

Occasionally adult P. citri would try to insert their stylets into isolated drops of water but the surface tension of the water seemed to prevent them from doing so. Drops of cacao sap dried out too rapidly for any such attempts to be observed. Fifteen stylets or stylet tracks of mealybugs have been traced in hand sections of tissue. Only thick sections show the tracks in their full length, the parts of tracks in thin sections are difficult to identify as such. Three tracks ended in vascular tissue but it was not possible to decide whether they ended in the xylem or phloem because of the thickness of the sections. The other twelve stylets or tracks ended in other types of tissue. Other stylets and their tracks observed seemed likely to belong to other species of insects.

Studies on "Die Back" of Cocoa

Studies have continued on the effects of varying factors on the spread of lesions resulting from the insertion of a needle contaminated with Fusarium decemcellulare Brick into the stems of cacao seedlings of various ages. Mild viruses, which caused no reduction in growth of seedlings did not affect the rate of growth of the fungus. There was a marked reduction in fungal growth in seedlings that had been infected with a severe virus for six months, compared with that in non-infected seedlings. This growth reduction may have been the direct effect of

the virus on the fungus and/or due to the fact that the seedlings infected with a severe virus were smaller in height and girth than virus-free plants of a similar age. The growth of the fungus was greater during the acute phase of infection of a severe virus than in the chronic phase of infection, but fungal growth during both these phases was less than in non-infected controls. During the first three weeks after inoculation growth was only half as extensive in normally cultivated Amazon seedlings, as it was in similar plants which had been inoculated with a severe virus, given limited watering and grown in soil of a high PH and in intense competition with maize seedlings.

There was little difference in the rate of fungal growth in the different parts of a cocoa tree. In the first week the amount of growth was greater in fan than in chupon tissues but after three weeks it was approximately the same. The growth of the fungus in lesions made in the internodes of seedlings was more variable than in similar lesions made in the nodes.

Using a multiple inoculation technique it has been found that there is a monthly variation in the percentage of infection points that show dieback, and when more results are available it is hoped to relate this variation to environmental factors. The percentage of dieback arising from multiple inoculations made into Amelonado trees naturally infected with virus was less than that in trees recently infected with the same virus by grafting. There was considerable variation in the rate at which dieback occurred in individuals in both sets of trees. In the first two weeks, 30% of the inoculated twigs on the naturally infected trees and 45% on the graft infected twigs had died back to the point of inoculation; after 8 weeks 40% and 55% of inoculated twigs had died back in these two classes of trees respectively. Subsequent dieback was negligible.

The growth rate of natural occurring dieback has been measured on trees naturally infected with virus, on trees graft-infected with virus, and non-infected trees. Throughout a period of five months both the number of dieback areas that increased in size and the amount of increase of dead wood were similar in the non-infected and graft-infected trees but were lower in those which had been naturally infected.

Leaf Tip Necrosis:

During a visit to the British Cameroons a study was made of the extent and cause of cacao leaf tip necrosis. This disease was found in varying degrees of severity on mature Amelonado, Trinitario and Amazon cacao grown under various

conditions of shade and soil, and it was invariably associated with the presence of a fungus (a Colletotrichum sp.). This condition has since been observed on mature cacao both in the Eastern Region and at Ibadan.

AGRONOMY SECTION

MOOR PLANTATION

Rainfall

Rainfall records for the quarter are compared with eleven year means.

	April	May	June	
1959	4.60	5.32	6.86	inches
11 yr. mean	5.93	6.15	6.67	"

Cushion Gall

One pollarded tree has produced two further galls, no galls or other abnormal features have been noticed on the remaining trees. Seedlings which have been grafted with cushions from affected trees in plot C6, and from Amazon cacao at INA farm are growing normally.

A further case of cushion gall was examined on farmers' cacao near Uhumoke some fifty miles east of Benin. The six year old Amelonado cacao in the plot was just coming into bearing. Larger galls were observed on six trees; these and several trees with abnormal cushion growth will be kept under observation.

AGODI CACAO EXPERIMENTAL FARM

Nursery Trial

Measurements were taken of the seedlings in this experiment before planting in the field in June. In Table I, the height measurements for the shade treatments are compared with those recorded in February.

Table I. Mean height per plant (cms.)

	No Shade.	Light Shade.	Heavy Shade.
February 1959	20.3	25.1	23.9
June 1959	48.2	50.3	37.8

The "no shade" and "light shade" treatments have been extremely good growth and seedlings in both treatments are markedly greater than those in the "heavy shade" treatment. The fertiliser rates applied to the plots proved excessive, as in manured seedlings a reduction in growth resulted. The treatment was discontinued after two applications. This experiment has now been continued in the field at Araromi Aperin in the form of an

establishment trial. There are six replications of the twelve treatment combinations. There are 24 seedlings per plot, planted at 8 feet by 8 feet. The effects of the various treatments on establishment will be observed.

Koroboto Seedling Experiments

In the first experiment the treatment differences described in Annual Report, W.A.C.R.I. 1958-59, have been maintained. Table II shows the mean girths and heights in the virus treatments and in the healthy controls.

Table II.

Girth	Control	Mild Virus	Severe Virus
1.6.59	2.02	1.91	1.79 cms.
Height			
21.5.59	161.6	147.7	129.7 cms.

No significant effects of irrigation or fertiliser have been noted. Measurements of Calonectria lesion lengths are being taken.

In the second experiment, indications that growth under the light shade (now no shade) treatment would surpass that under heavy shade have been confirmed and the effect has become significant. This is a reversal of the situation observed during early growth and in the dry season. Mean height per plant in January, February and May are listed in Table III.

Table III.

	Heavy Shade	Light Shade	
15.1.59	84.60	82.62 cms.	Difference significant at P = 0.05.
14.2.59	88.58	88.10 cms.	
23.5.59	117.96	129.99 cms.	Difference significant at P = 0.01.

The latter difference is confirmed by other growth measurements. It seems clear in this case that the need for shade was confined to the early growth period, and that in the present cooler, wetter conditions shade can be dispensed with.

The effect of virus on growth has increased, but it has been noted that the reduction in growth caused by virus under heavy shade is relatively less than that under light shade. The interaction between shade and virus being significant at P = 0.01 (degrees of freedom for error - 40). Mean heights per plant in the virus treatments and healthy controls under the two shade treatments are given in Table IV.

Table IV.

23.5.59	Healthy Controls	Mild Virus	Severe Virus	
Light Shade	148.60	134.39	106.90	cms.
Heavy Shade	127.04	121.21	105.63	cms.

The Calonectria-inoculated plants have been harvested, and measurements of lesion lengths made. Analysis of the data revealed no significant effects, although there is an indication that lesion length was greater in virus infected seedlings. Mean lesion lengths are listed in Table V.

Table V.

	Healthy Controls	Mild Virus	Severe Virus
Mean Calonectria lesion length (cms)	36.15	39.34	40.74

Kay (Annual Report, W.A.C.R.I. 1958-59) has recently discussed the limitations of this single inoculation technique. The variability in the results of this method is evident in the present experiment, and future work is planned, using the multiple inoculation technique described by Kay (loc. cit.). Here actual dieback is measured externally, and it is not necessary to destroy the seedlings as it is in order to measure lesion length.

Measurements of total length of lateral roots were made on each plant removed during thinning. It is clear that virus has reduced total root length (see Table VI.) though no statistical analysis of the data has yet been made.

Table VI.

Mean Total Lateral root length per plant (cms.)

Healthy Controls	Mild Virus	Severe Virus
295.4	273.9	242.6

This result is in agreement with the findings of Goodall (Ann. Appl. Biol. 1949) who stated that virus infection caused necrosis of the fine roots of cacao.

Alakia Seedling Experiment

A further field experiment has been laid down to study the effect of virus on cacao seedlings growing under different ground covers. This experiment consists of five replications of four treatments; viz:

A. A sward of vigorous grass.

B. Natural regeneration of weed growth (mainly Dicotyledons).

C. Grass mulch on bare soil.

D. Bare soil.

Each main plot contains 81 seedlings planted at four feet by four feet. These plots are divided into four sub-plots, each containing sixteen seedlings, leaving a single guard row between sub-plots. On these sub-plots there is a 2^2 factorial layout of virus inoculation versus no inoculation and fertiliser application versus none. Three blocks are planted with progeny of a vigorous Amelonado hybrid, and two with F3 Amazon seedlings. Seedlings were selected for uniformity before planting in June, and the main plot treatments have been applied. Fertilizer and virus treatments will be applied when the ground cover in treatments A and B is established.

Araromi Aperin

In 1957, some eight acres of land were leased by the Ministry of Agriculture at Araromi Aperin, plantain and Gliricidia shade was planted in 1958. The plot has been handed over to W.A.C.R.I. and the following three experiments have been planted.

Virus Tolerance/Resistance Experiment.

A field experiment has been planted with four of the supposedly virus tolerant varieties received from Tafo. Plots of Amazon and Amelonado cacao have been included as controls. There are six replications of the six treatments. Seedlings were graded so that height differences within varieties were associated with blocks.

Fertiliser trial

A 2^4 N.P.K.Mg. factorial fertiliser trial with the third order interaction confounded has been laid down. Planting material was progeny of a vigorous Amelonado hybrid, and seedlings were selected for uniformity before planting. Planting distance is 8 feet by 8 feet. There are five replications of the two groups of treatments, and twenty seedlings per plot. No fertiliser is to be applied this season, but growth measurements will be made on the seedlings throughout the year for calibration purposes.

Nursery/Establishment trial

Seedlings from the Agodi nursery trial have been planted as described above.

CTQ.